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APPENDIX E
AQUIFER TESTING AND ANALYSES

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APPENDIX E
AQUIFER TESTING AND ANALYSES

E.1 SLUG TESTING

Slug tests were performed in observation wells GB-1 through GB-6, and GB-8, between January 5 and 16, 2004, by a Shannon & Wilson hydrogeologist. Water level data were recorded using a Minitroll™ data logger/pressure transducer system. Three falling head and three rising head tests were performed in each well. A semi-log plot of the slug testing data is provided on Figures E-1 through E-7. The Bouwer and Rice (1976 and 1989) method was used to analyze the slug test data.

Slug tests provide a relatively simple means of estimating the horizontal hydraulic conductivity of the saturated sediments immediately surrounding the screened or open portion of a well. The influence of a slug test extends only a short distance into the soils surrounding the well screen, and the area tested is relatively small compared to that influenced by a larger-scale pumping test. Slug tests do not provide data regarding large-scale aquifer hydraulic conductivity, aquifer geometry, or boundary conditions affecting groundwater flow.

Slug testing involves rapidly raising or lowering the water level in a well and measuring the subsequent change in water level as it recovers to the original static position. Raising the water level in a well is achieved by quickly lowering a slug (in this case, either a sealed, 4.0-foot-long or 8.0-foot-long, 1.25-inch-diameter, polyvinyl chloride [PVC] pipe filled with silica sand) to displace water in the well. The subsequent falling of the water level to the original static position is referred to as a falling head slug test. Removing the slug and monitoring the rising water level constitutes a rising head slug test.

Hydraulic conductivity estimates for the geologic units in the immediate vicinity of each slug tested well are summarized below.

TABLE E-1
SUMMARY OF SLUG TEST RESULTS

Exploration Number	Unit(s) Tested by USCS Designation	Hydraulic Conductivity, K, (cm/s)
GB-1	SM	6×10^{-4} to 8×10^{-4}
GB-2	SM-SP	7×10^{-4} to 2×10^{-3}
GB-3	PT	1×10^{-5} to 2×10^{-5}
GB-4	GM	2×10^{-4} to 3×10^{-4}
GB-5	PT/ML	2×10^{-5} to 7×10^{-4}
GB-6	PT/SM	3×10^{-4} to 4×10^{-4}
GB-8	PT	3×10^{-5} to 1×10^{-4}

Notes:

cm/s = centimeters per second.

USCS = Unified Soil Classification System

E.2 INFILTRATION TESTING

Two well infiltration tests were performed in observation well TH-1 between January 19 and 23, 2004, by a Shannon & Wilson hydrogeologist. Well infiltration tests may be used to estimate the horizontal hydraulic conductivity of the saturated sediments in the near-well vicinity using a variety of analytical methods. The influence of an infiltration test extends farther from the well than a slug test, but is still relatively small compared to the influence of a large-scale pumping test. Observation wells MW-1 and MW-2 were utilized as groundwater level monitoring points. These monitoring points are 5 feet and 10 feet in radial distance from TH-1.

Constant head well infiltration tests involve adding water to a well and monitoring over time the inflow rate that is required to maintain the water in the well at a relatively constant level.

Groundwater level changes in surrounding monitoring wells can also be monitored for additional information. Clean tap water from a poly-tank in a pickup was used to supply water for the tests. Inflow rates were measured with a 2-liter graduated cylinder and a stopwatch. Constant head water levels were maintained in TH-1 to within ± 1 inch of the top of the well casing. Water level data were recorded using a Minitroll™ data logger/pressure transducer in each well.

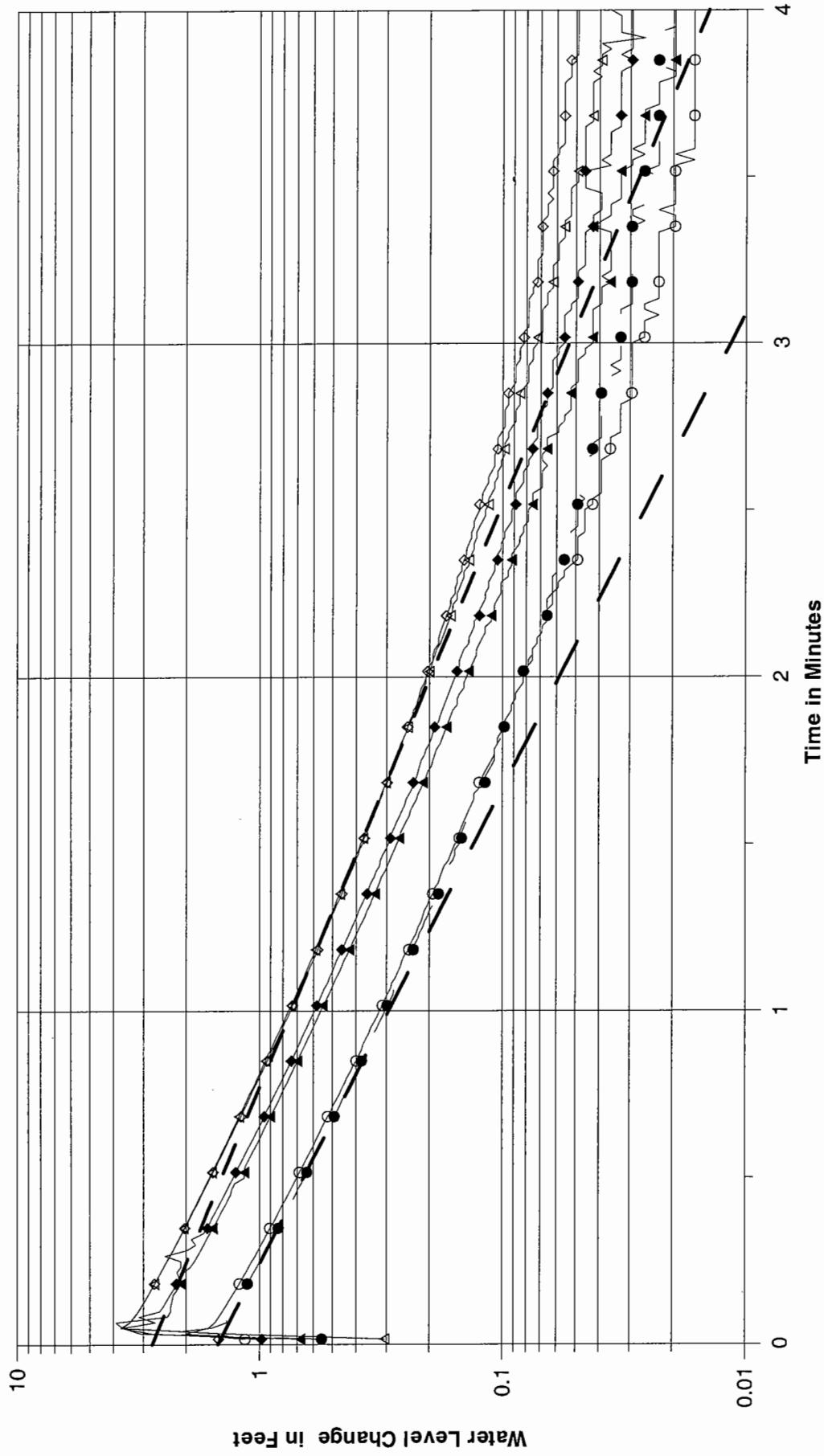
The first infiltration test lasted for approximately 2 hours (with approximately 22 hours of monitoring). This test was conducted to qualitatively assess the short-term aquifer response. Based on this test, a longer second test was conducted, lasting for approximately 12 hours (with approximately 50 hours of monitoring).

Infiltration test data plots are provided on Figures E-8 through E-13.

E.3 REFERENCES

Bouwer, Herman, 1989, The Bouwer and Rice slug test – An update: Ground Water, vol. 27, no. 3, May-June, p. 304-309.

Bouwer, Herman, and R. C. Rice, 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells: Water Resources Research, vol. 12, no. 3, June, p. 423-428.

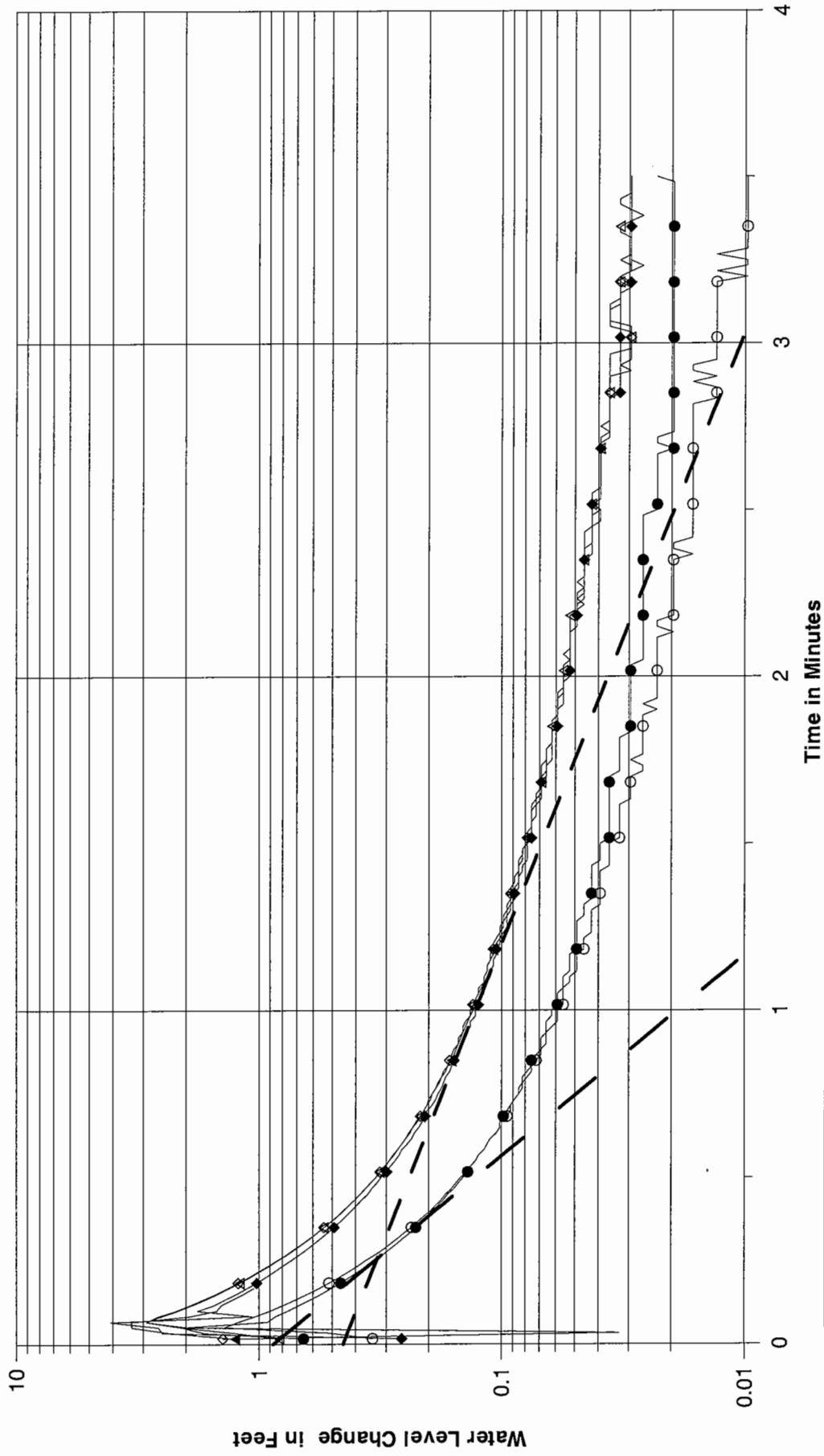


Seattle Public Utilities Greenwood Subsurface Characterization Study Seattle, Washington	SLUG TEST DATA PLOT OBSERVATION WELL GB-1	April 2004	21-1-09915-005
		SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	FIG. E-1

Legend

- ▲ Long Slug, Falling Head, Test 1
- △ Long Slug, Rising Head, Test 1
- Short Slug, Falling Head, Test 2
- Short Slug, Rising Head, Test 2
- ◆ Long Slug, Falling Head, Test 3
- ◊ Long Slug, Rising Head, Test 3
- Max. Best Fit Equation: $\ln(Y) = -1.6 * X + 0.39$
- Min. Best Fit Equation: $\ln(Y) = -1.3 * X + 1.0$

FIG. E-1



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**SLUG TEST DATA PLOT
OBSERVATION WELL GB-2**

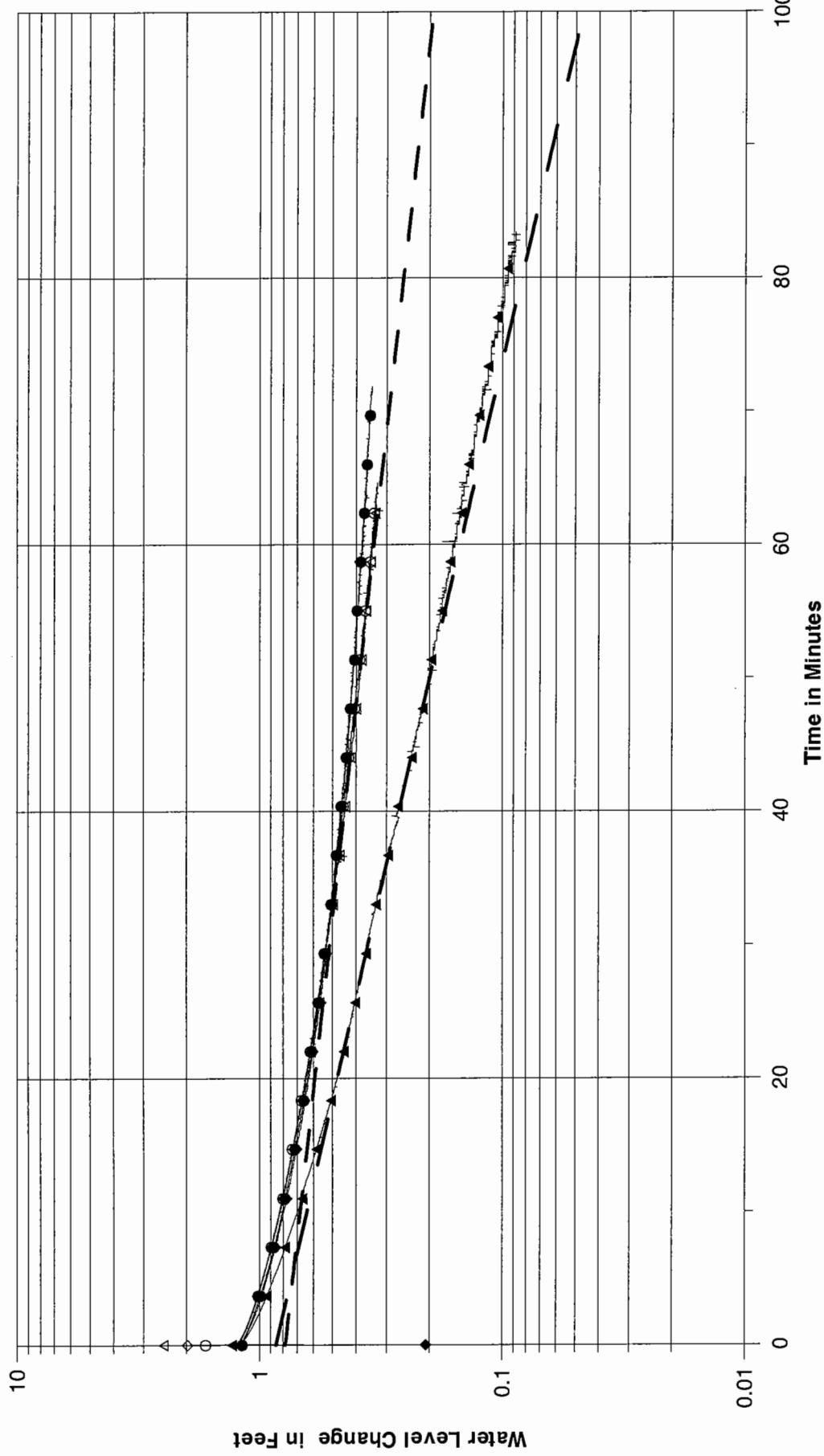
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FIG. E-2

FIG. E-2



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**SLUG TEST DATA PLOT
OBSERVATION WELL GB-3**

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FIG. E-3

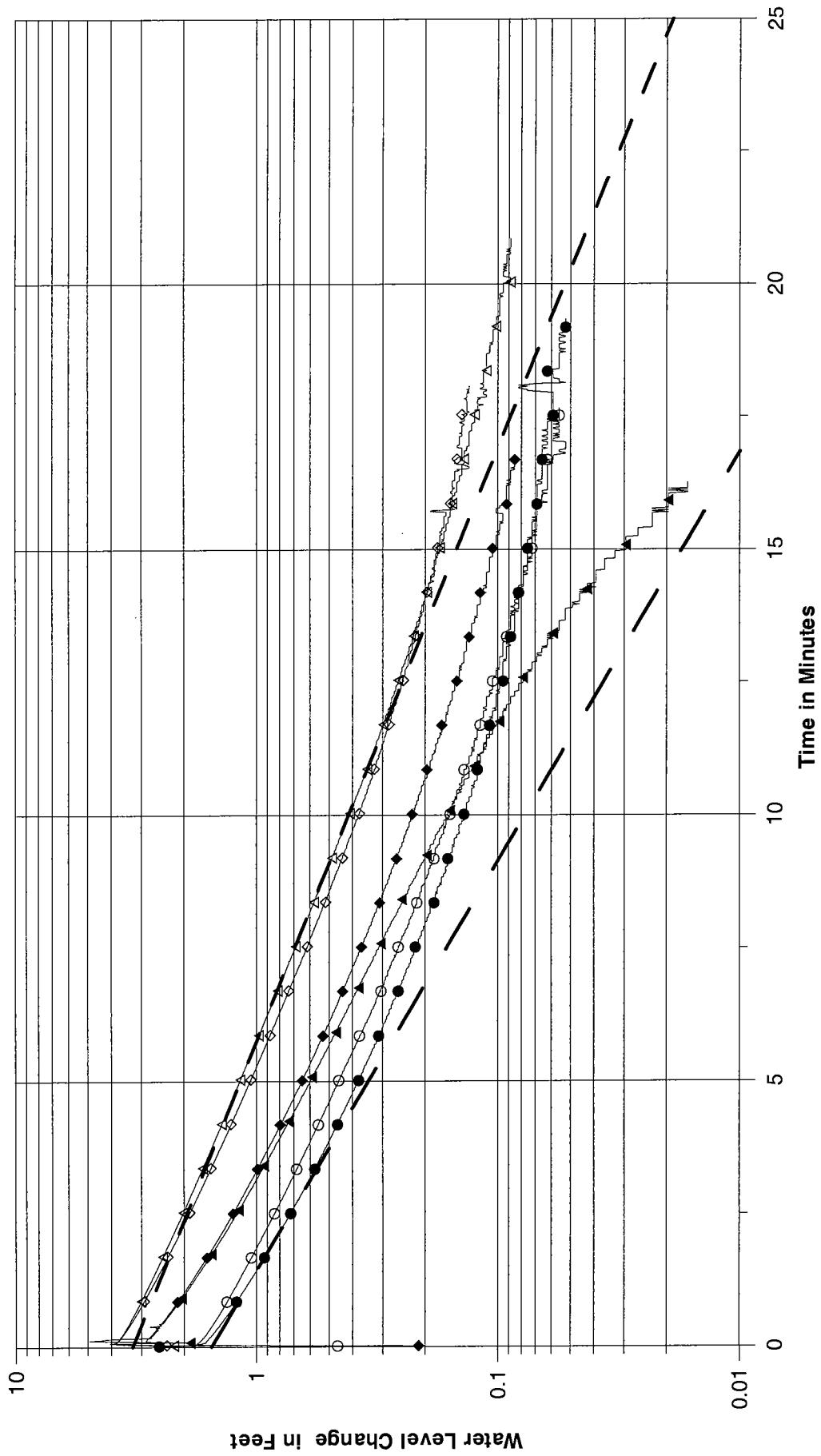
Legend

- ▲ Long Slug, Falling Head, Test 1
- △ Long Slug, Rising Head, Test 1
- Short Slug, Falling Head, Test 2
- Short Slug, Rising Head, Test 2
- ◆ Long Slug, Falling Head, Test 3
- ◇ Long Slug, Rising Head, Test 3

Max. Best Fit Equation: $\ln(Y) = -0.029 * X - 0.15$

Min. Best Fit Equation: $\ln(Y) = -0.014 * X - 0.24$

FIG. E-3



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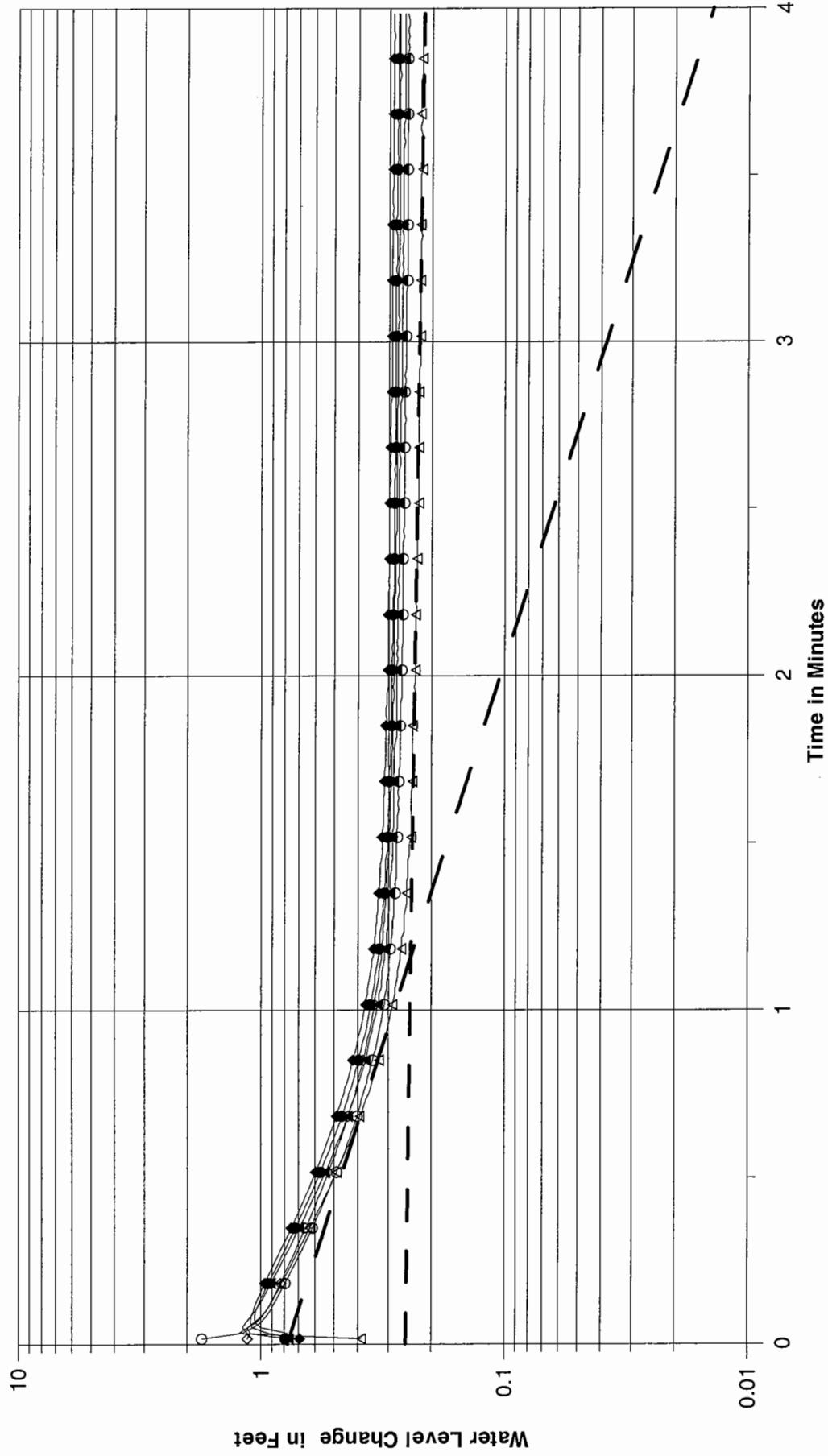
**SLUG TEST DATA PLOT
OBSERVATION WELL GB-4**

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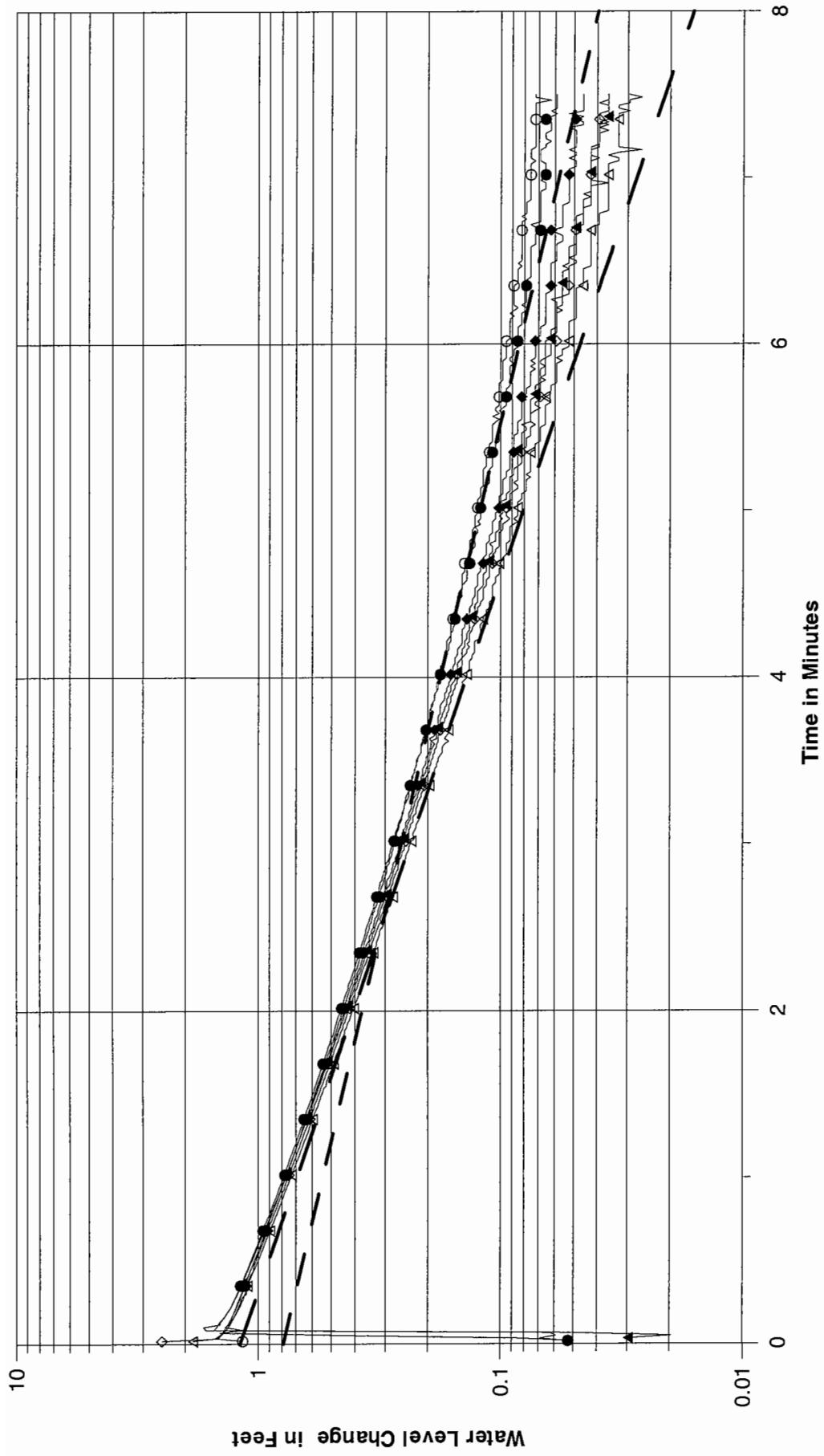
21-1-09915-005

FIG. E-4



Seattle Public Utilities Greenwood Subsurface Characterization Study Seattle, Washington	SLUG TEST DATA PLOT OBSERVATION WELL GB-5
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FIG. E-5



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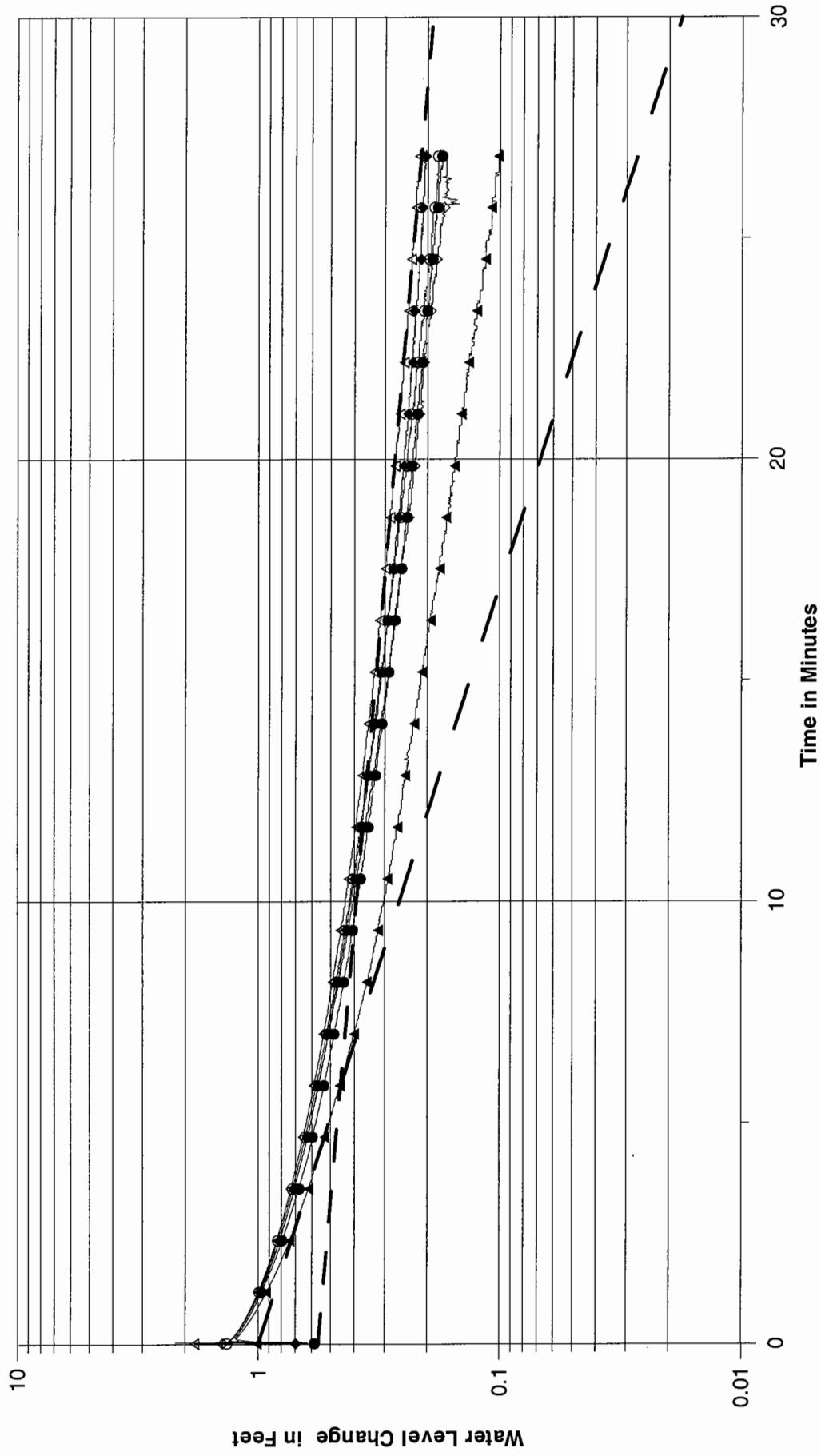
**SLUG TEST DATA PLOT
OBSERVATION WELL GB-6**

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FIG. E-6



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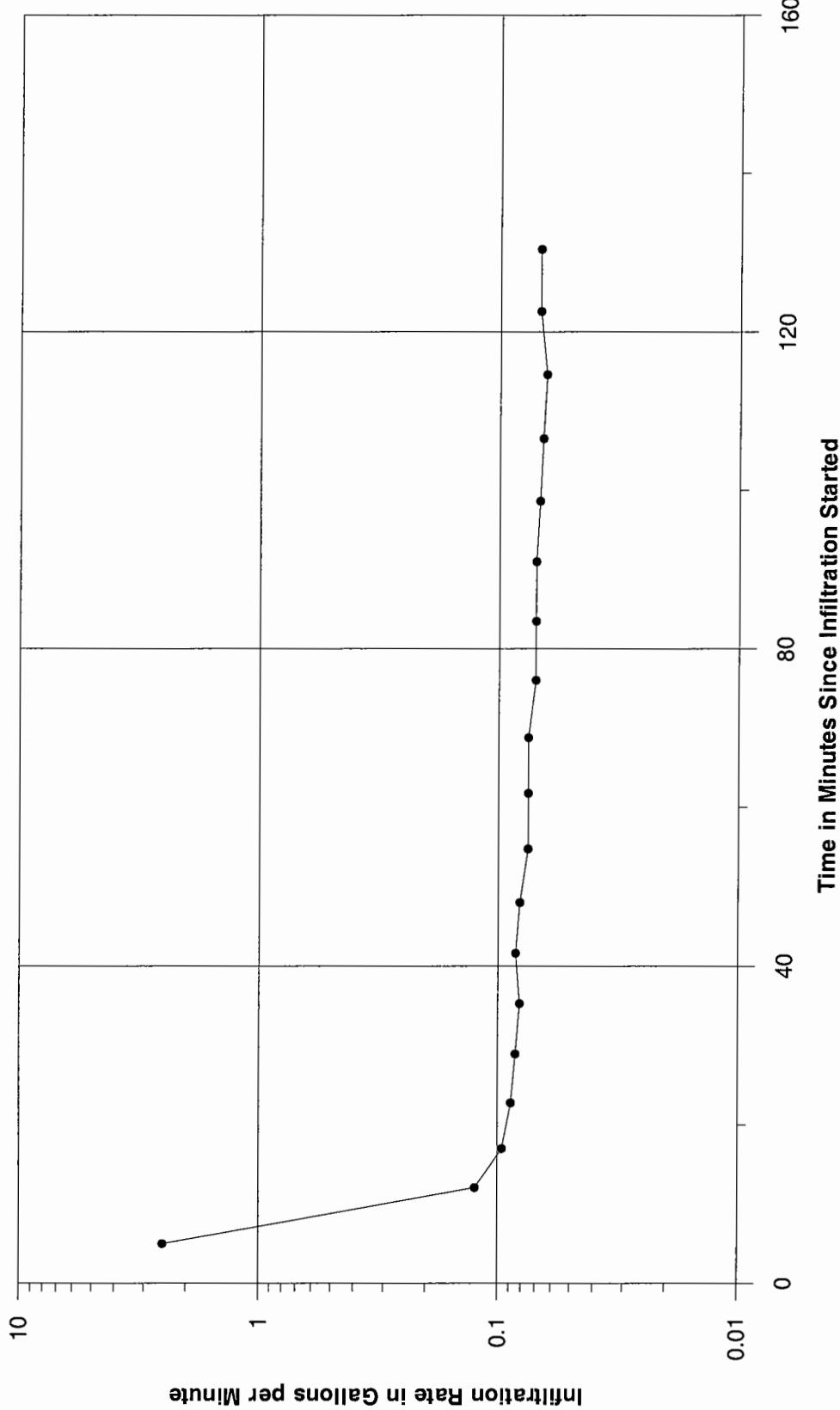
**SLUG TEST DATA PLOT
OBSERVATION WELL GB-8**

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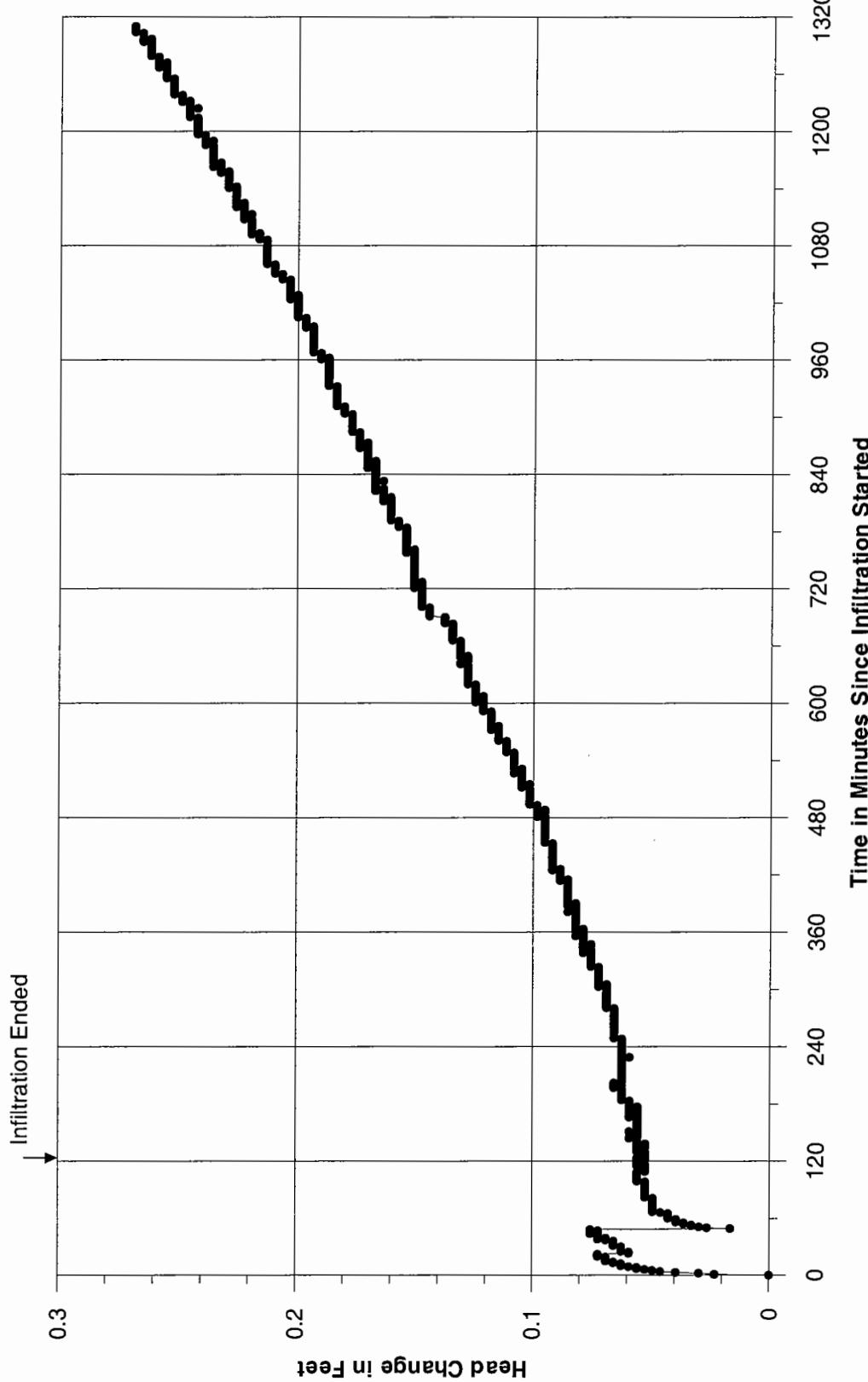
21-1-09915-005

FIG. E-7



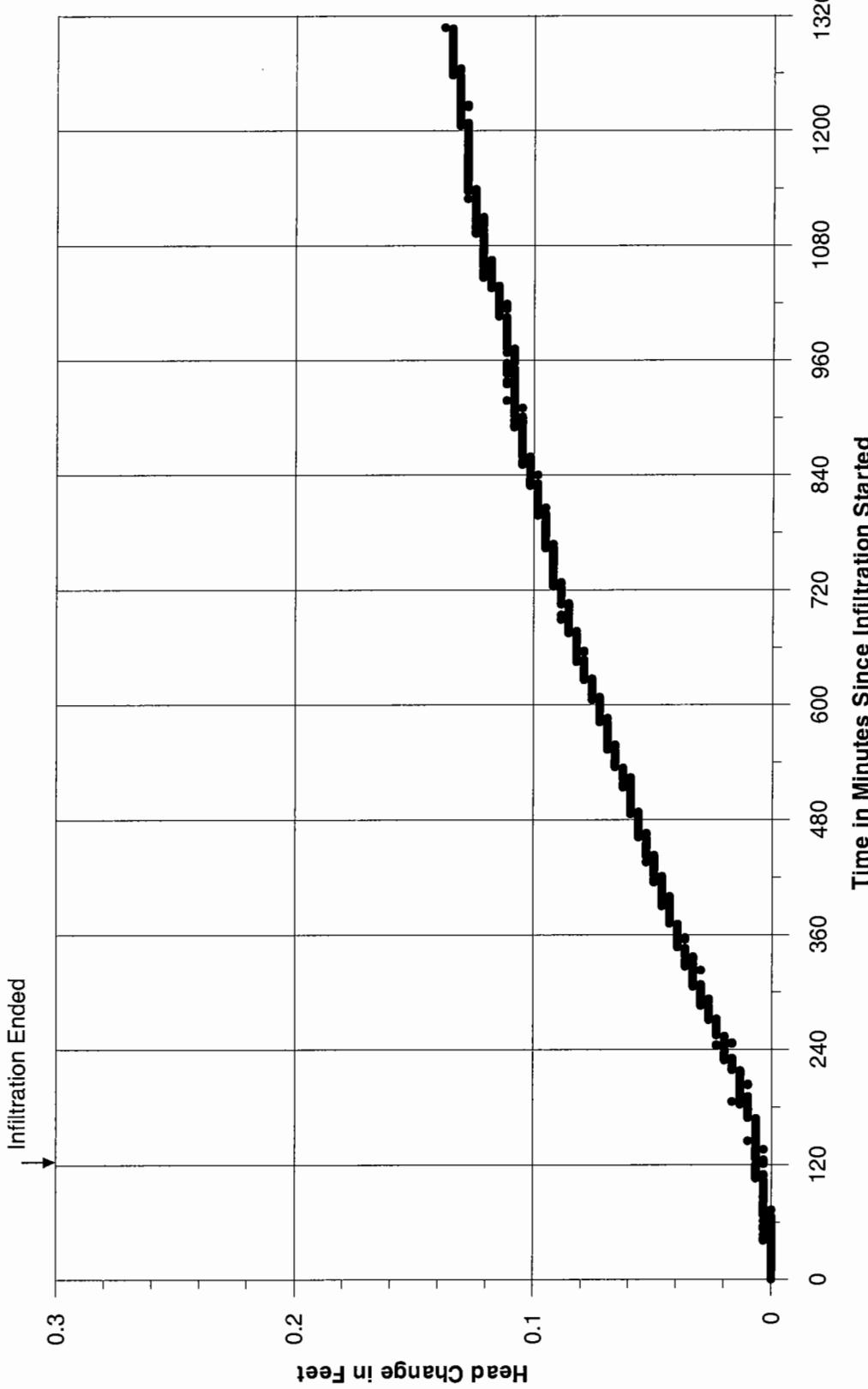
Seattle Public Utilities Greenwood Subsurface Characterization Study Seattle, Washington	2-HOUR INFILTRATION TEST DATA PLOT INFILTRATION RATE v. TIME OBSERVATION WELL TH-1	April 2004	21-1-09915-005
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	FIG. E-8	SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	FIG. E-8

FIG. E-8



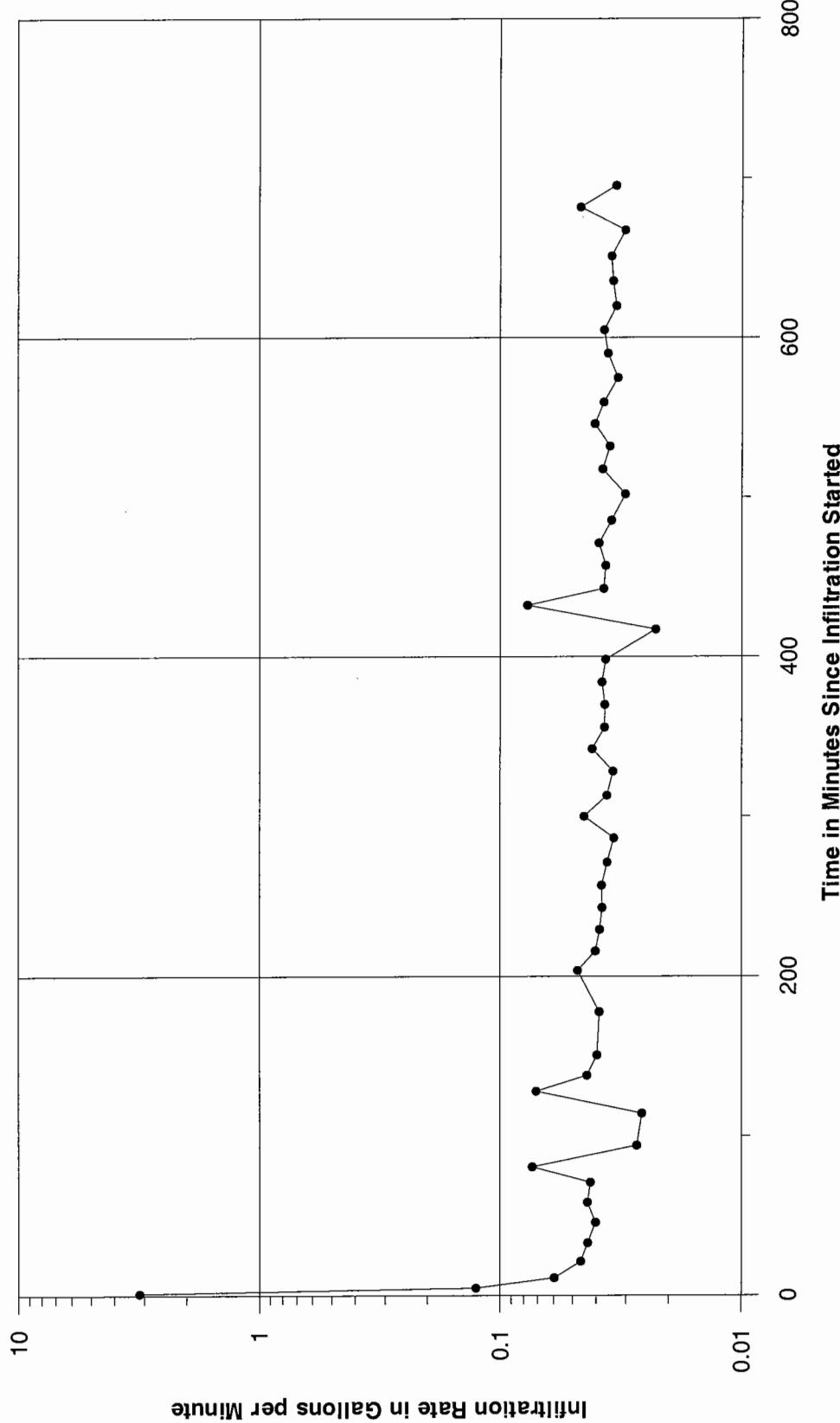
Seattle Public Utilities Greenwood Subsurface Characterization Study Seattle, Washington	2-HOUR INFILTRATION TEST DATA PLOT HEAD CHANGE v. TIME OBSERVATION WELL MW-1	April 2004 21-1-09915-005	SHANNON & WILSON, INC. <small>Geotechnical and Environmental Consultants</small>	FIG. E-9
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FIG. E-9



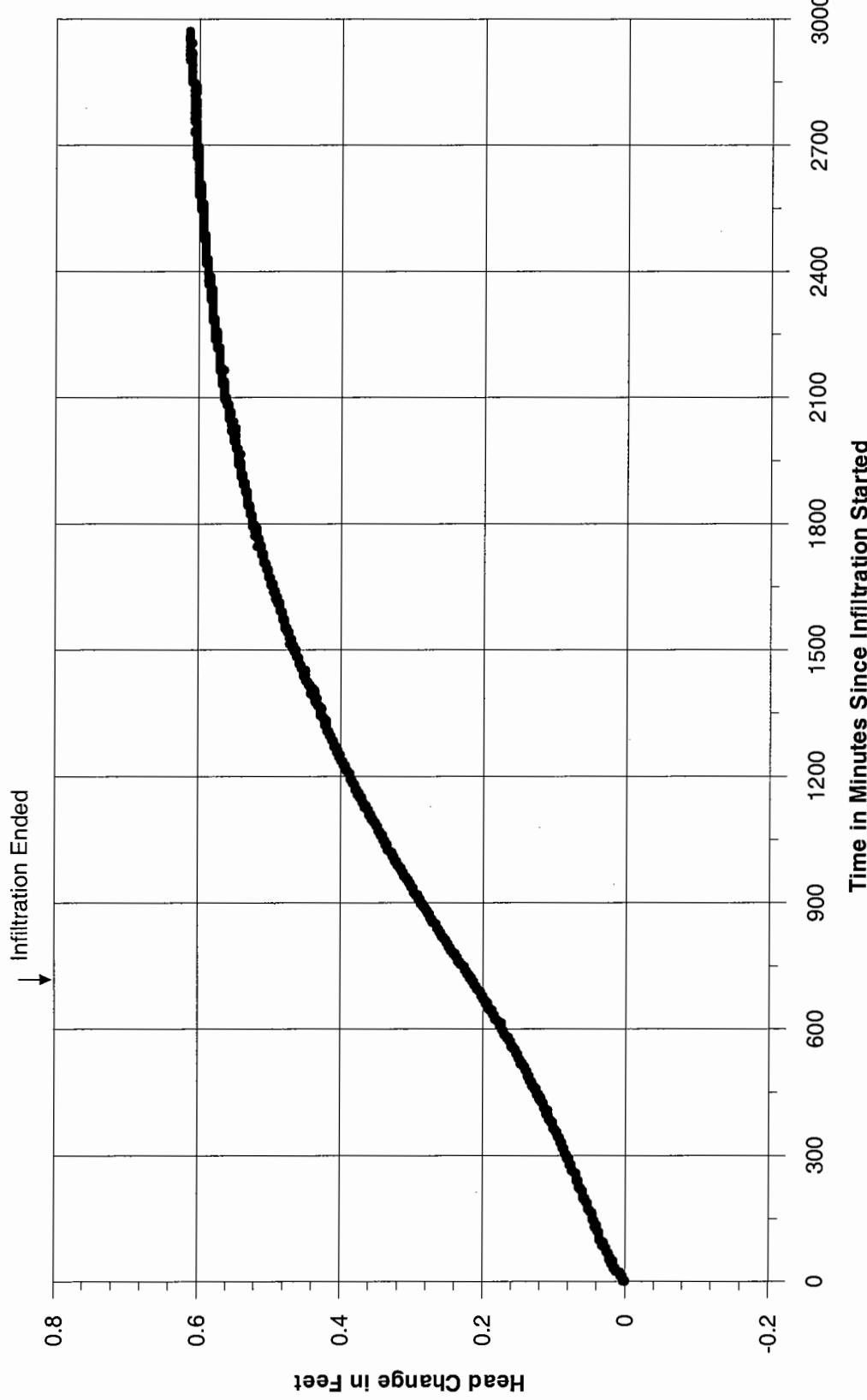
Seattle Public Utilities Greenwood Subsurface Characterization Study Seattle, Washington	2-HOUR INFILTRATION TEST DATA PLOT HEAD CHANGE v. TIME OBSERVATION WELL MW-2	FIG. E-10
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FIG. E-10



12-HOUR INFILTRATION TEST DATA PLOT	
Seattle Public Utilities	Greenwood Subsurface Characterization Study
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	INFILTRATION RATE V. TIME
	OBSERVATION WELL TH-1
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FIG. E-11



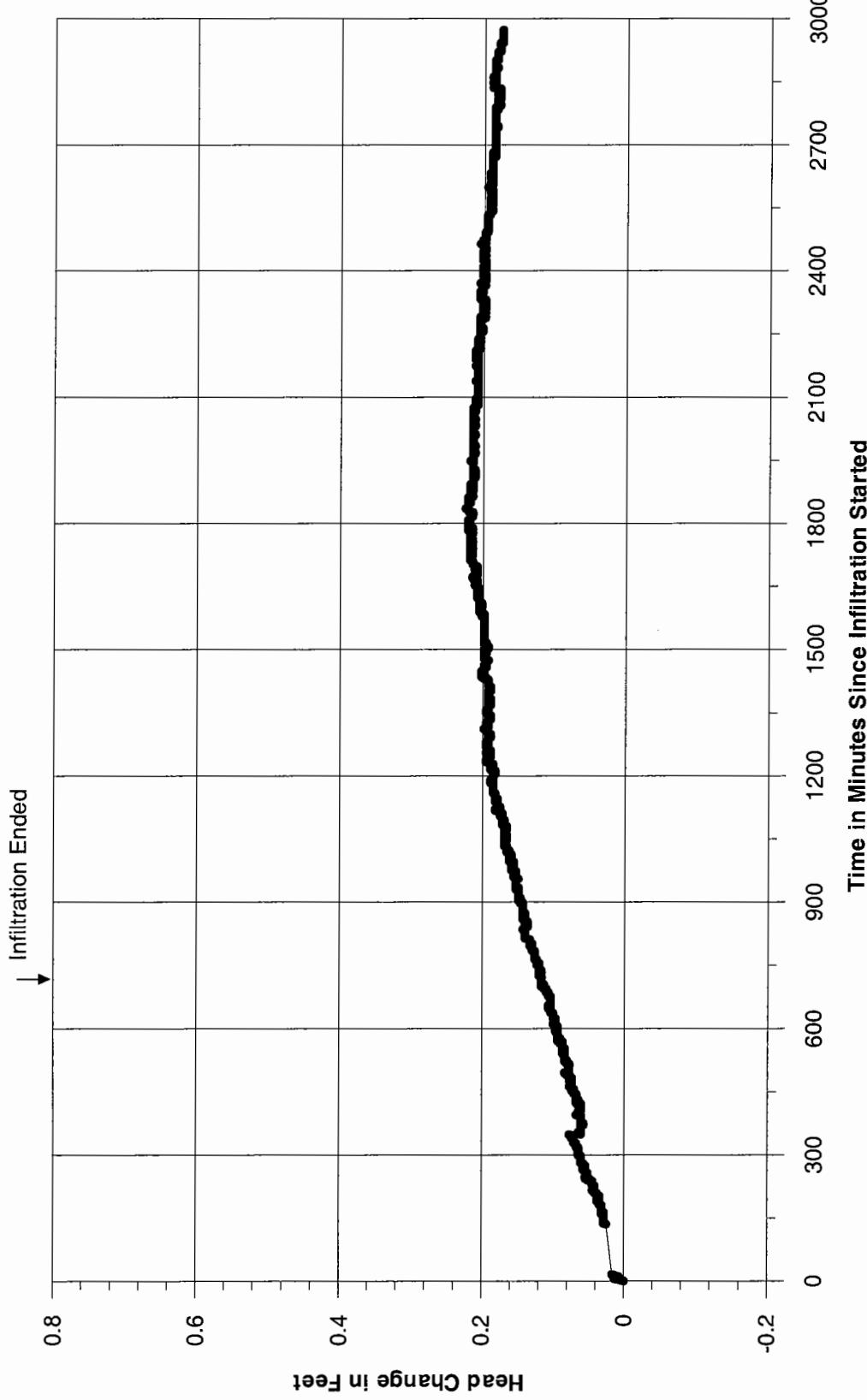
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12-HOUR INFILTRATION TEST DATA PLOT
HEAD CHANGE v. TIME
OBSERVATION WELL MW-1

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FIG. E-12 **FIG. E-12**



Seattle Public Utilities Greenwood Subsurface Characterization Study Seattle, Washington	12-HOUR INFILTRATION TEST DATA PLOT HEAD CHANGE v. TIME OBSERVATION WELL MW-2	April 2004	21-1-09915-005
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FIG. E-13